1923

APRIL, 1923 BULLETIN 383

NEW JERSEY

AGRICULTURAL EXPERIMENT STATIONS

TEN YEARS OF POTATO SPRAYING IN NEW JERSEY

IMPERIAL BUREAU OF MYCOLOGY 31 OCT. 1923

WILLIAM H. MARTIN

NEW BRUNSWICK
NEW JERSEY

NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS*

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Ten Years of Potato Spraying in New Jersey

WM. H. MARTIN, PH.D., *Plant Pathologist*

The value of spraying potatoes with Bordeaux mixture has been demonstrated in many sections of the country, especially in those states where epidemics of late blight are commonly experienced. In some of the potato growing states, however, and particularly those in New England, increased yields usually follow the application of Bordeaux mixture even in the absence of late blight. These increases have been sufficiently large to indicate that in these states it is advisable to spray every year in order to insure maximum crop returns.

In New Jersey the presence or absence of late blight is dependent almost entirely on weather conditions. During the past thirty-four years there have been eighteen years when this disease has been present and in some instances it has been responsible for a total crop loss in various parts of the state. While late blight is not found every year and when present, is not always severe, there are other foliage diseases, such as early blight and tip burn, that exact heavy toll from the potato crop. The losses from early blight and tip burn are exceptionally large in some years and, while not so great in others, are usually sufficient to warrant the adoption of control measures. As in the case with late blight, both of these diseases can be controlled by spraying with Bordeaux mixture.

In view of the losses experienced by the potato growers of the state a series of spraying tests have been conducted by the New Jersey Agricultural Experiment Station to determine if spraying is practical under New Jersey conditions. During the time in which the tests have been conducted, various phases of potato spraying have been considered, including a comparison of home-made and commercial Bordeaux mixtures, most efficient time of applying the spray mixture, the number of applications necessary for best results, strength of Bordeaux mixture to use, and a comparison of Bordeaux applied in the form of a dust and a liquid. In view of the fact that the year 1922 marks the close of ten years' work, it has been deemed advisable to summarize the results in one publication. The data given in this bulletin are taken from the Annual Reports of the Experiment Station for the years indicated.

The first potato spraying experiments in New Jersey were conducted in 1895 by Dr. B. D. Halsted. In tests conducted in that year and in 1896 he compared the fungicidal value of various materials and found that Bordeaux mixture gave most efficient control of early blight. In 1913 the tests to determine the value of spraying potatoes were resumed by Dr. Mel. T. Cook and Dr. T. J. Headlee in co-operation with G. W. Martin; in 1914 Dr. T. J. Headlee and A. E. Cameron of the Department of Entomology conducted a series of tests in co-operation with the Department of Plant Pathology. In 1915 and 1916 the work was done by Dr. H. C. Lint, in 1917 by Dr. Mel. T. Cook, in 1918 by Dr. L. M. Massey and from 1919 to date by the writer.

Test in 1913

The work this year was conducted to determine the relative efficiency of various fungicides and insecticides. The machine used for applying the spray mixtures was equipped with 3 nozzles to a row and sprayed 4 rows at a time. A pressure of 50-60 pounds was maintained. The dusts were applied with a duster that dusted 6 rows.

The field in which the test was conducted was planted with the Irish Cobbler, an early variety. All of the plots received four applications of spray or dust. The home-made Bordeaux mixture remained on the vines much better than any of the other preparations while Pyrox was second best in this respect. After July 1 flea beetles were very numerous on all of the plots and did much damage. Early blight was first observed July 1 and by July 10 had become rather common on all the plots. On July 22 the vines sprayed with Bordeaux mixture were still green, those dusted were dead, those sprayed with Kil-tone and Electro-Bordo Lead practically so, while those sprayed with Pyrox still had a slight amount of green in the stems. The yield and treatment of the various plots is shown in table 1.

TABLE 1

Results of Tests at Elmer—1913

Irish Cobbler Variety

Treatment	Yield per Acre	Treatment	Yield per Acre
	bu.		bu.
Bordeaux mixture	318.5	Sulfur 3, lead arsenate, dust 1	339.4
Kil-tone	299.0	Sulfur 2, lead arsenate, dust 2	334.4
Pyrox	327.0	Sulfur 1, lead arsenate, dust 3	326.1
Electro-Bordo lead	315.3	Lead, arsenate of (check)	340.0

The results apparently favor the use of the sulfur-lead dusts over the copper compounds. There are several factors, however, other than the spray or dust treatments that contributed to the differences in yield noted between the various plots. Just after the potatoes came up they were injured by frost, the damage being more severe on that side of the field in which the Bordeaux mixture plot was situated. In addition the dusted plots were planted with a more vigorous strain of seed than were the other plots.

Tests in 1914

Three tests were conducted this year, one with the Irish Cobbler, one with the American Giant and the other with the Green Mountain variety. The purpose of the work was to determine the relative value of spraying and dusting for the control of diseases and insects.

Test at Elmer

The test at Elmer was conducted with the Irish Cobbler variety. The field was divided into five plots and the various plots received four appli-

cations of the materials tested. Flea beetles were present in large numbers on May 27, the time of the first treatment.

On June 10 and again on July 16 counts were made of the number of flea beetle punctures on the various plots. The results of these counts are shown in table 2.

TABLE 2

EFFECT OF SPRAYING AND DUSTING ON FLEA BEETLE CONTROL AT ELMER

Treatment	Date of Observation	Average Number of Punctures per Leaf	Date of Observation	Average Number of Punctures per Leaf
Untreated (check)	June 10	154.5	Aug. 22	32
Bordeaux, lead arsenate	June 10	92.0	July 16	15
Kil-tone	June 10	142.0	July 16	28
Lead arsenate	June 10	138.0	July 16	21
Sulfur, lead arsenate dust	June 10	208.4	July 16	28

The difference in number of punctures observed on June 10 and July 16 is accounted for by the fact that the former counts were made on the large radical leaves of the vines which suffer greater cumulative damage than the younger leaves of the top shoots, which alone were considered in the later counts.

The yield per acre of the various plots and the cost per acre per application of the different materials is given in table 3.

TABLE 3

RESULTS OF TESTS AT ELMER—1914

Irish Cobbler Variety

Treatment	Yield per Acre	Cost per Application
	bu.	
Bordeaux, lead arsenate	275.6	$1.55
Kil-tone	214.5	2.14
Sulfur, lead arsenate, dust	233.5	2.16
Lead arsenate (check)	212.7	1.26

Test at Freehold

In this test the American Giant variety was sprayed four times, the first application being made on May 21 and subsequent ones at 10-day intervals. There was a small amount of tip burn present in the experimental area with a trace of early blight on the plots sprayed with home-made and commercial Bordeaux mixtures and a heavy outbreak on the plots dusted with lead arsenate and sulfur, lead arsenate.

The treatment of the various plots, the yield per acre, and the cost per acre per application are shown in table 4.

TABLE 4

RESULTS OF TEST AT FREEHOLD—1914

American Giant Variety

Treatment	Yield per Acre	Cost per Application
	bu.	
Bordeaux, lead arsenate	286.6	$1.10
Sulfur, gypsum, lead arsenate, dust.	277.8	.96
Lead arsenate (check), dust	283.3	2.67
Ansbacher's Bordeaux	281.6	1.28

As in the Elmer test, counts were made on the various plots to determine the number of flea beetle punctures. The results of these counts are presented in table 5.

TABLE 5

EFFECT OF SPRAYING AND DUSTING ON FLEA BEETLE CONTROL AT FREEHOLD

Treatment	Date of Count	Average Number of Punctures
Untreated (check)	July 1	7.7
Untreated (check)	July 9	9.0
Bordeaux, lead arsenate	July 9	4.9
Lead, Ansbacher's Bordeaux	July 10	7.15
Lead arsenate, dust	July 10	6.3
Sulfur, gypsum lead arsenate, dust.	July 10	7.7

Test at Robbinsville

In this test the Green Mountain variety was sprayed three times beginning May 27-28. Throughout the summer, the vines on the plots sprayed with the home-made Bordeaux were superior to those receiving the other treatments and, on Aug. 16 the plants on these plots were still green while those on the other plots were dead. The yield of the various plots as well as the cost per acre per application of the different materials is given in table 6.

TABLE 6

RESULTS OF TEST AT ROBBINSVILLE—1914

Green Mountain Variety

Treatment	Yield per Acre	Cost per Application
	bu.	
Bordeaux, lead arsenate	290.3	$1.70
Sulfur, zinc arsenate (check), dust.	240.0	2.01
Gypsum, zinc arsenate, dust	248.9	2.33
Electro-Bordo Lead	256.9	1.98

On July 13 counts of flea beetle injury similar to those made at Elmer and Freehold were made. The number of punctures found on the various treatments were, Bordeaux-lead-arsenate 8.9, Electro-Bordo Lead 21.5, Gypsum-Zinc-Arsenate 13.5, and Sulfur-Lead-Arsenate, 15.

Tests in 1915

Four tests were conducted this year on the commercial crop, two with the Irish Cobbler, one with the State of Maine and one with the American Giant variety. In addition, a test was conducted with the Irish Cobbler variety planted late in the season, the so-called second crop, grown for seed purposes.

Test at Elmer

In this test with the Irish Cobbler variety a comparison was made of commercial and home-made Bordeaux mixtures and two sulfur dusts.

The various plots were run in duplicate and each plot received four spray or dust applications, the first one being made when the plants were about 8 inches high. Subsequent treatments were made at 10-day intervals with the exception of the third, a 23-day period elapsing between the second and third applications.

No diseases were observed until about the time the vines started to die when a few scattered infections of early blight were found. On July 18 the vines sprayed with the home-made and commercial Bordeaux mixtures were greener and more vigorous than those on the plots dusted with the sulfur-zinc or sulfur-lead dusts.

The yield and treatment of the various plots is given in table 7.

TABLE 7

RESULTS OF TEST AT ELMER—1915

Irish Cobbler Variety

Treatment	Yield per Acre
	bu.
Bordeaux	389.1
Kil-tone	395.0
Sulfur, lead arsenate, dust	380.5
Sulfur, zinc arsenate, dust	387.2
Lead arsenate (check)	393.7

Test at Mount Holly

This test was conducted with the Irish Cobbler variety. The treatment of the various plots as well as the yield per acre is shown in table 8.

TABLE 8

RESULTS OF TEST AT MOUNT HOLLY—1915

Irish Cobbler Variety

Treatment	Yield per Acre
	bu.
Sulfur dust	273.6
Bordeaux mixture	306.0
Sulfur, zinc dust	296.0
Tonicide	254.6
Lead arsenate (check)	248.6
Bordeaux mixture	270.6

No diseases were apparent in the field in which the test was conducted until about July 1 when a yellowing of the vines followed by a leaf wilt was noted. This trouble was less severe on the Bordeaux and sulfur-zinc plots than on the lead arsenate, tonicide and sulfur-lead plots. In this test, home-made Bordeaux mixture proved to be superior to any of the other materials used.

Test at Freehold

The test at Freehold was with a late variety, the American Giant. The work was restricted to a comparison of home-made Bordeaux mixture and sulfur-lead and sulfur-zinc dusts, these latter were made up at the rate of 5 parts of the sulfur to 1 part of the arsenate of lead or zinc. The check plots were dusted with a mixture of Paris green and lime. The yield of the various plots is shown in table 9.

TABLE 9

RESULTS OF TEST AT FREEHOLD—1915

American Giant Variety

Treatment	Yield per Acre
	bu.
Paris green (check)	408.0
Sulfur, zinc arsenate, dust	403.0
Sulfur, lead arsenate, dust	429.5
Bordeaux mixture	410.9

No foliage diseases appeared, but late in the season the stems of the vines on the plots sprayed with Bordeaux mixture were still green when those on the dusted plots were dead.

Test at Jamesburg

This test was planned to demonstrate the value of spraying with Bordeaux mixture over spraying with an arsenical alone. The State of Maine variety was sprayed three times with home-made Bordeaux mixture made up at the rate of 10 lbs. of copper-sulfate and 10 lbs. of stone lime

to 75 gallons of water. This mixture was used owing to the fact that the sprayer would deliver only 75 gallons of material per acre. The average yield of the plots sprayed with Bordeaux mixture plus arsenate of lead was 258.2 bushels as compared with 266.0 bushels for those plots sprayed with arsenate of lead alone.

Spraying late crop potatoes—Test at Elmer

This test was conducted with late planted Irish Cobblers. The materials tested were home-made Bordeaux mixture, sulfur-lead and sulfur-zinc dusts. The various plots included in the test received three applications of the spray and dust materials. The average yield of the plots sprayed with Bordeaux mixture was 281.8 bushels and of those sprayed with arsenate of lead 236.7 bushels per acre, an increase of 45.1 bushels in favor of the former. The plots dusted with sulfur-zinc and sulfur-lead dusts showed corresponding increases amounting to 7.6 and 9.4 bushels respectively. In this test early blight was present in abundance, being observed in the field before the first spray application was made. The disease was effectively controlled by Bordeaux mixture and to a much lesser extent by the sulfur dusts.

Tests in 1916

Spraying tests were conducted this year with the Irish Cobbler, American Giant and Green Mountain varieties.

The year was not especially favorable for obtaining large differences from spraying since both insect and fungous pests were at a minimum and the seasonal conditions were especially conducive to the production of maximum yields.

Test at Elmer

This test was conducted with the Irish Cobbler variety. The field was divided into 37 plots, each 8 rows wide. Four spray applications were made on the dates of May 27, June 6, June 17, and June 29. The materials used and the yield per acre for the various plots is shown in table 10.

TABLE 10

RESULTS OF TEST AT ELMER—1916

Irish Cobbler Variety

Treatment	Yield per Acre
	bu.
Kil-tone	386.0
Bordeaux mixture	382.1
Lead, arsenate (check)	368.0
Sulfur, lead arsenate	367.0
Pyrox	364.7
Lime-sulfur	362.6

Test at Mount Holly

This test was conducted with the Irish Cobbler variety. The field was divided into 27 plots each eight rows wide. The various plots were sprayed four times, on the following dates, June 1, 12, July 10, 28. The various treatments and the yield per acre are shown in table 11.

TABLE 11

Results of Test at Mount Holly—1916

Irish Cobbler Variety

Treatment	Yield per Acre
	bu.
Bordeaux mixture	225.2
Hydroxcide	226.4
Kil-tone	182.9
Lead arsenate (check)	217.8
Sulfur, lead arsenate	187.8
Paris green	171.5

Test at Farmingdale

The purpose of this test was to determine the relative value of spraying the American Giant and Irish Cobbler varieties with Bordeaux mixture. The purpose of the test was defeated, however, in that four spray applications were made on the former and only three on the latter. The various treatments and the yield per acre are shown in table 12.

TABLE 12

Results of Tests at Farmingdale—1916

Irish Cobbler and American Giant Varieties

Treatment	Yield per Acre	
	Irish Cobbler	American Giant
	bu.	bu.
Kil-tone	228.0	348.5
Bordeaux mixture	271.2	369.2
Lead arsenate (check)	261.4	372.4
Sulfur, lead arsenate	240.2	346.3

Test at Jamesburg

This test was conducted with the Green Mountain variety. The various plots were sprayed four times. The materials used and the yield per acre is shown in table 13.

TABLE 13

RESULTS OF TEST AT JAMESBURG—1916

Green Mountain Variety

Treatment	Yield per Acre
	bu.
Sulfur, lead arsenate, dust	213.7
Bordeaux mixture	213.1
Lead arsenate (check)	210.3
Sulfur, lead arsenate liquid	200.5

In this test the wet and dry sulfur-lead treatments were made at the same rate, 30 pounds per acre. It is interesting to note that the dusted plots outyielded the sprayed plots by 13.2 bushels.

Test with Late Crop

The purpose of this test, conducted at Elmer, was to determine the effect of spraying late planted Irish Cobblers. No diseases appeared on either the check or treated plots. The materials used and the yields per acre are shown in table 14.

TABLE 14

RESULTS OF TEST AT ELMER—1916

Irish Cobbler Variety, Late Crop

Treatment	Yield per Acre
	bu.
Bordeaux mixture	163.5
Lead arsenate	151.0
Unsprayed (check)	154.7
Kil-tone (modified)	172.1
Kil-tone	164.8
Sulfur, lead arsenate	158.4

Tests in 1917

Three tests were conducted this year, two with the commercial crop and the third with late crop Cobblers. The tests were restricted to a comparison of commercial and home-made Bordeaux mixtures. The spray applications in these tests were made by the growers.

Test at Dayton

In this test six plots were sprayed with Bordeaux mixture plus arsenate of lead, and alternate plots, serving as checks, with arsenate of lead alone. Each plot was sprayed three times. The average yield of the plots receiving Bordeaux mixture was 178.5 bushels as compared with 175.1 bushels for those sprayed with arsenate of lead.

Test at Elmer

In the test at Elmer two spray applications were made. The various treatments and the average yield for each were 309.1 bushels for Bordeaux mixture, 316.3 bushels for Kil-tone, and 313.3 bushels for arsenate of lead.

Test with Late Crop

In the field in which this work was conducted no diseases appeared until July, when heavy rains brought on a severe outbreak of tip burn. This was followed by excessive amounts of early blight. The yield per acre for the various treatments were 217.5 bushels for Bordeaux mixture plus arsenate of lead, 224.1 bushels for Kil-tone, and 210.5 bushels for the untreated plots.

Tests in 1918

One spraying test with the Irish Cobbler variety was conducted this year at Vincentown. The various plots included in the test were sprayed three times, on May 27, June 5 and June 15. A slight amount of early blight and some tip burn were present but no difference in the amount of these troubles was to be observed on the various plots.

A period of drought accompanied by a heavy infestation of aphids beginning about June 1 and continuing for six weeks, caused the early and premature ripening of the vines. The treatment of the various plots and the yield per acre is shown in table 15.

TABLE 15

Results of Test at Vincentown—1918

Irish Cobbler Variety

Treatment	Yield per Acre
	bu.
Bordeaux mixture and arsenate of lead	148.7
Arsenate of lead (check)	154.0
Adheso-Green label (commercial bordeaux)	145.5
Tiger brand Bordeaux-lead (commercial bordeaux)	141.5

Tests in 1919

Three tests were conducted this year; one with the commercial crop American Giant, the second with the commercial crop Irish Cobbler and the third with late planted Irish Cobblers. In the field in which this work was conducted late blight appeared for the first time in the potato spraying tests conducted in New Jersey. As would be expected, marked increases in yield resulted on the plots sprayed with Bordeaux mixture.

Test with the Commercial Crop at Elmer

The test at Elmer was with the Irish Cobbler variety. The field was divided into 10 plots, each 4 rows wide. To eliminate differences that might arise from soil variations a check plot was alternated with every two treated plots. Each treatment with its check was repeated 3 times. The check plots were sprayed with arsenate of lead at the rate of 6 pounds to 100 gallons of water. Two spray mixtures were used, home-made Bordeaux mixture of the standard 5-5-50 formula plus arsenate of lead at the rate of 6 pounds to 100 gallons and a Zinc-Bordeaux, furnished by the General Chemical Company of New York. The mixtures were applied with a traction sprayer that developed 150 lbs. pressure. For the first application two nozzles to the row were used, for subsequent ones three were used. Each of the various plots received five spray applications. The first was made May 31 when the plants were about 6 inches high. At the time of the second application, June 10, the plants were 18 inches high and were still free from diseases. The third and fourth applications were made on July 17 and 27 respectively. On the latter date, there was considerable early blight and tip burn on the check plots with smaller amounts on the sprayed plots. At the time of the last applications, July 7, there was a decided contrast between the sprayed and the unsprayed plots. On July 22 an examination of all the plots was made to determine the percentage of dead leaves; this was done by making counts on every tenth plant in the center row of each plot. On the plots sprayed with arsenate of lead 89 per cent of the leaves were dead, as compared with 44 and 27 per cent on those sprayed with the home-made and commercial Bordeaux mixtures. The dying of the leaves was due to tip burn and a heavy infestation of early blight. The plots sprayed with arsenate of lead yielded 216.0 bushels; those sprayed with the home-made Bordeaux, 265.3 bushels; and those sprayed with the commercial Bordeaux, 268.6 bushels per acre.

In this test five applications of home-made Bordeaux mixture gave increased returns of 49.3 bushels per acre over plots sprayed with an arsenical alone, while those sprayed with the commercial mixture showed an increase of 52.6 bushels.

Test with the Commercial Crop at Holmdel

This test was conducted with the American Giant variety. The mixtures used were calcium arsenate, arsenate of lead, Paris Green and Bordeaux mixture. The arsenate of lead was applied at the rate of 6 pounds per acre and the other insecticides were used in such proportions as to give equivalent amounts of arsenic. This phase of the work was under the direction of the Department of Entomology. Home-made Bordeaux of the 5-5-50 formula was applied at the rate of 100 gallons per acre. All of the various materials were applied with a power sprayer that developed from 200 to 250 pounds pressure. The plots were laid out in such a manner that a check plot, sprayed with arsenate of lead, alternated with each two treated plots. Five spray applications were made on May 16, 27, June 5, 12, 20. Prior to June 20 there were no differences apparent between the various plots. After that date, those sprayed with Paris Green became

heavily infected with early blight while only a trace of this trouble was found on the other plots. Late in the summer the plots sprayed with arsenate of lead were decidedly better than those sprayed with Bordeaux mixture. The average yields of the plots receiving the various treatments is shown in table 16.

TABLE 16

Results of Test at Holmdel—1919

American Giant Variety

Treatment	Yield per Acre
	bu.
Arsenate of lead (check)	262.8
Paris Green	235.1
Bordeaux mixture	228.3
Calcium arsenate	227.2

In connection with the comparison of the different spray mixtures a test was conducted to determine the most efficient pressure of applying spray material. The sprays were applied at 150 and 250 pounds pressure. The yields of the plots so treated are shown in table 17.

TABLE 17

Influence of Pressure on Efficiency of Spray Materials—(Holmdel)

Treatment	Yield per Acre	
	150 Pounds Pressure	250 Pounds Pressure
	bu.	bu.
Bordeaux mixture	215.7	227.5
Arsenate of lead (check)	258.9	266.6
Calcium arsenate	253.4	200.9

The plots sprayed with Bordeaux mixture at 250 pounds pressure gave an increase of 11.8 bushels per acre over those sprayed at 150 pounds pressure. The results obtained with the insecticides are contradictory and no conclusions can be drawn from the data at hand.

Test with the Late Crop

This test was conducted at Elmer with late planted Irish Cobblers. The field was without irregularities and was divided into 19 plots, each 4 rows wide. The arrangement of the plots was such that a check plot alternated with each spray plot. The check plots were unsprayed, since no insects were present, and the treated plots were sprayed four times with home-made Bordeaux mixture of the 5-5-50 formula. The first application was made September 12 when the plants were 9 inches high. At the

time of the second application, September 19, there was a slight amount of early blight on the check plots. The third application was made September 29. At this time three plants infected with late blight were found on the check plots. At the time of the fourth application, October 9, 75 per cent of the leaves on the check plots were affected with late blight while only a trace showed on the sprayed plots. A thorough examination made of the field on October 21 showed that only 3 per cent of the leaves on the sprayed plots were dead while all of the leaves on the two center rows of the check plots were dead. The average yield of the check plots was 132.6 bushels and of the sprayed 183.4 bushels per acre, a gain of 50.8 bushels in favor of the spray treatment.

Tests in 1920

The purpose of the potato spraying test on the commercial crop this year was to determine the relative efficiency of 5-5-50 and 4-4-50 Bordeaux mixtures for the control of early blight and tip burn and also to determine the value of early and late spray applications.

The test with the late crop was designed to determine the relative value of spraying the Irish Cobbler and American Giant varieties. In previous tests, while increased yields resulted from spraying the former variety with Bordeaux mixture, negative results have for the most part been obtained in tests conducted with the latter variety. To determine if varietal differences in any way influence the results secured, the test was conducted with the two varieties planted side by side. The purpose of the test was defeated, however, since late blight made its appearance.

Test at Elmer

This test was conducted with the Irish Cobbler variety to determine the value of various amounts of copper for the control of tip burn and early blight. The standard 5-5-50 mixture was compared with a 4-4-50 mixture. In both cases the sprays were applied at the rate of 100 gallons per acre. Five spray applications were made. The first was made June 8 when the plants were about 6 inches high and the second, third and fourth were made on June 18, 29 and July 9, respectively. No disease had appeared up to this time. At the time of the fifth application, July 22, the plots receiving the copper sprays were still green while the unsprayed plots were heavily infected with tip burn and early blight. On August 3 counts of the number of dead leaves were made on the various plots with the following results:

Plot.	Leaves Dead.	Average Yield Per Acre.
5-5-50 Bordeaux mixture	70.3%	281.4 bu.
4-4-50 Bordeaux mixture	76.3%	266.0 bu.
Check (lead arsenate)	93.3%	260.3 bu.

The second part of this test was conducted in the same field to determ-

ine the value of early and late spray applications for the control of tip burn and early blight. The check plots were sprayed with arsenate of lead alone and the sprayed plots with 5-5-50 Bordeaux mixture. The plots receiving the early applications were sprayed on June 8, 18 and 29 and those receiving the late applications on June 29, July 9 and 22.

As in the previous test, a count was made August 3 to determine the number of dead leaves on the various plots. This showed that 98 per cent of the leaves on the check plots were dead, 91 per cent on the plots receiving the early applications and 75 per cent on the plots receiving the late application.

The average yield of the check plots was 259.4 bushels per acre; of the plots receiving the early applications, 240.3 bushels per acre; and of those receiving the late applications, 273.1 bushels per acre. In this connection it is interesting to compare the yield of these plots with those in the same field which received 5 applications. The average yield of the check plots in these two tests was 260.3 and 259.4 bushels per acre, indicating that there was little difference in the soil in various parts of the field. The average yield of the plots sprayed five times with Bordeaux mixture was 281.4 bushels, for those receiving three late applications, 273.1 bushels and for those receiving 3 early applications 240.3 bushels per acre.

Test with Late Crop

In this test the Irish Cobbler and American Giant varieties, planted in the same field, were sprayed 5 times with 5-5-50 Bordeaux mixture. The dates of the various applications are September 8, 12 and 27 and October 7 and 18.

Late blight appeared on the unsprayed plots the last of September, and by October 18 most of the leaves were dead. On that date a count was made on the Irish Cobbler variety of the number of dead leaves, 94 per cent were dead on the check plots compared with 27 per cent on the plots sprayed with Bordeaux mixture and 68 per cent on those sprayed with arsenate of lead. The average yield of the unsprayed plots was 163.9 bushels; of the plots sprayed with arsenate of lead, 175.2 bushels; and of those sprayed with Bordeaux mixture, 199.3 bushels per acre.

Counts similar to those made on the Irish Cobblers were made on the American Giants. On the unsprayed check plots 62 per cent of the leaves were dead as compared with 12 per cent on the plots sprayed with Bordeaux mixture. The average yield of the former plots was 150.4 bushels per acre as compared with 178 bushels for the latter.

Tests in 1921

This year in addition to the tests with home-made Bordeaux mixture the scope of the work was broadened to include tests of several copper-lime dusts. The summer of 1921 was quite dry and very unfavorable for the normal development of the potato crop. Very few serious foliage diseases were observed, tip burn being the only foliage trouble present in any amount on the commercial crop. Serious reductions in yield were experienced, however, as result of a heavy infestation of aphids.

Test at Elmer

In this test with the Irish Cobbler variety, one series of plots was sprayed three times with Bordeaux mixture on the following dates: June 13, 20 and July 1. A second series of plots received an additional application on July 8. The check plots were sprayed with arsenate of lead. The first spray application was made when the plants were about seven inches high. No late blight and only a trace of early blight was present in the field; tip burn, however, was quite severe.

The sprayed plots remained green for a longer period than those unsprayed and the plots receiving 4 applications remained green longer than those receiving 3 applications. The average yields of the various plots were 148.3 bushels on the check, 201.9 bushels for the three applications of Bordeaux mixture, and 229.5 bushels for the four applications of Bordeaux mixture.

Test at Bridgeton

The purpose of this test was to compare home-made Bordeaux mixture with a 20-80 copper-lime dust and also to determine the relative efficiency of early and late spray applications. One series of plots was sprayed with 5-5-50 Bordeaux mixture on May 26, June 1 and 13 and a second series on June 20 and 29. A third series of plots was sprayed on each of these dates, receiving five applications in all. On June 29 the leaves on many of the plants were yellow as a result of the very dry weather. There was no early blight, but considerable tip burn. Flea beetles were very numerous, especially on those receiving the early spray applications and also on those dusted with the copper-lime dusts. The plots receiving the late applications and those sprayed five times were relatively free from the beetles.

The dusts were applied with a machine having only one outlet to the row and in order to apply a sufficient amount each row was dusted twice, once each way at each application. Owing to a break in the machine no dust application was made on June 1.

The yields of the various plots are shown in table 18.

TABLE 18

RESULTS OF TEST AT BRIDGETON—1921

Irish Cobbler Variety

Treatment	Yield per Acre
	bu.
Arsenate of lead (check)	118.8
5-5-50 Bordeaux on May 26, June 1, 13, 20, 29	129.7
5-5-50 Bordeaux on May 26, June 1, 13	132.9
5-5-50 Bordeaux on June 20, 29	130.7
Copper-lime Dust on May 26, June 13, 20, 29	118.8

Test at Plainsboro

The purpose of this test was to determine the value of dusting the American Giant variety with copper-lime dusts for the control of foliage diseases. Three dusts were used, as follows: 1. Dehydrated copper-sulfate, 20.80 (metallic copper 8%, tri-calcium arsenate 5.5%, inert ingredients 86.5%.) 2. Same composition as (1) with the exception that the amount of metallic copper present was reduced to 6 per cent and the inert ingredients increased to 88.5 per cent. 3. Arsenic oxide, 21-24 per cent; metallic copper 10.12 per cent; inert ingredients 25-30 per cent.

The check plots were dusted with arsenate of lead. Each dust was applied on two series of plots. The first series receiving applications on: May 24, June 1, 10, 16, July 2, 12, and the second, on May 24, June 1, 18.

At the time of the first application, May 24, the plants were 3-5 inches high and showed considerable flea beetle injury. On June 10 there was a serious outbreak of aphids. A thorough examination of all the plots, made on July 12, revealed the fact that the leaves on many of the plots were severely burned due to the very dry season, but there was no early blight present. There was some indication that the plots treated with dust 1 had been injured by the treatment.

The various plots were dug August 26. The yields of the check plots indicated that there was a considerable variation in the soil in different parts of the field. In view of this difference and the fact that the very dry season and an abundance of lice prevented normal yields it is questionable if any conclusions as to the value of the dusts can be drawn from the results. The average yield of the check plots was 107.7 bushels per acre as compared with 89.3 bushels for the plots receiving the all-season and early applications of dust 1. Plots treated with dust 2 showed no increase while dust 3 gave an increase of 9 bushels per acre.

Test with Late Crop

The purpose of this test was to determine the relative efficiency of Bordeaux mixture and copper-lime dusts for the control of foliage diseases. The test was conducted with the Irish Cobbler variety, planted July 25. The spray plots were sprayed with 5-5-50 Bordeaux mixture, applied at the rate of 100 gallons per acre. Two copper-lime dusts were tested, a 20-80 and a 15-85. These were applied with a hand duster and the plants thoroughly covered. The check plots were not treated since no insects were present. The dust and sprays were applied September 1, 10, 20, 27 and October 5, 14.

Early blight and tip burn were abundant and severe on the check plots early in the growing season. The plots sprayed with Bordeaux mixture showed very little of either of these troubles. While the two dusts held early blight in check in the early season, the plots treated with the dusts were little better than the checks later in the season. In table 19 is shown the average number of dead leaves on the various plots at intervals during the growing season and also the yield per acre for each plot.

TABLE 19

RESULTS OF TEST AT ELMER—1921

Irish Cobbler Variety (Late Crop)

Treatment	Dead Leaves			Yield per Acre
	Oct 5	Oct. 14	Oct. 21	
	per cent	per cent	per cent	bu.
Check	61.2	91.1	98.0	125.0
Bordeaux mixture	1.3	15.3	55.0	163.5
20-80 dust	14.0	43.3	88 0	144.1
15-85 dust	12.8	46.6	92.0	139.4

Other Tests with the Late Crop

Three spraying tests were conducted on late crop Irish Cobblers by the County Agent of Salem County, J. C. Crissey. In all of the tests 5-5-50 Bordeaux mixture was applied at the rate of 100 gallons per acre at a pressure of 175 pounds.

The average cost of making the spray treatments was $2.06 per acre per application. In all of these tests early blight and tip burn were present in considerable amounts. The yield per acre in bushels from the various tests is shown in table 20.

TABLE 20

RESULTS OF TESTS IN SALEM COUNTY—1921

Irish Cobbler Variety (Late Crop)

Test No.	Number of Applications	Yield of Treated Plot	Yield of Check Plot
		bu.	bu.
1	4	160.1	119.1
2	4	213.5	161.0
2	2	198.6	161.0
3	3	213.4	162.7

Tests in 1922

This year 2 spraying tests were conducted on the commercial crop, one with the American Giant and the other with the Irish Cobbler variety. The purpose of the former test was to compare home-made and commercial Bordeaux mixtures, spraying and dusting, and to determine the value of early and late spray and dust applications. In the latter test a comparison was made of early and late spray applications of 5-5-50 Bordeaux mixture.

Test at Freehold

In this test with the American Giant variety late blight was very abundant and severe. This was the first time that this disease had appeared on any of the spraying tests conducted with the commercial crop.

The sprays and dusts used were home-made 5-5-50 Bordeaux mixture applied at the rate of 100 gallons per acre and a commercial Bor-

deaux powder (Kil-tone) applied at a rate that gave equivalent amounts of metallic copper to that contained in the home-made material. Two dusts were included in the test, a commercial Bordeaux that carried 22.5 per cent metallic copper and a copper-lime dust carrying 6 per cent. Both of these materials were applied at a rate that gave equivalent amounts of metallic copper to that applied in the liquids. The check plots were sprayed with arsenate of lead.

In addition to the various materials tested, a comparison was made of early and late applications of both sprays and dusts. One series of plots received 3 applications on June 7, 15, and 26,—while another series received additional applications on July 6, 14, 24 and Aug. 5.

No foliage diseases were observed in the field until July 6, when late blight was found on the check plots. The trouble increased in severity as the summer advanced. On August 2 a count was made of the number of dead leaves on the various plots. The average for the unsprayed plots was 92 per cent; for those sprayed with home-made Bordeaux mixture, 5 per cent; for Kil-tone (liquid), 24 per cent; for Kil-tone (dust), 72 per cent; and for copper-lime dust, 70 per cent. A marked difference was likewise apparent between the number of dead leaves on the plots receiving the early spray and dust applications and those receiving late applications. On plots receiving seven spray applications, 5 per cent were dead as compared with 77 per cent on those sprayed three times. On the plots dusted seven times 70 per cent were dead, while on those dusted three times 91 per cent were dead.

The average yield of the plots receiving the various treatments and the number of dead leaves on August 2 are shown in table 21.

TABLE 21

Results of Test at Freehold—1922

American Giant Variety

Treatment	Number Dead Leaves August 2	Yield per Acre
	per cent	bu.
Lead arsenate (check)	92	280.9
Bordeaux mixture, 3 applications	77	271.8
Bordeaux mixture, 7 applications	5	350.3
Kil-tone (liquid), 7 applications	24	307.4
Kil-tone (dust), 7 applications	72	301.1
Copper-lime, 3 applications	91	300.7
Copper-lime, 7 applications	70	263.7

In this test a series of plots were included that were sprayed with home-made Bordeaux mixture plus calcium caseinate. This material was used at the rate of ¾ pound to 100 gallons of Bordeaux. The average yield of the plots so treated was 402.3 bushels per acre as compared with 350.3 bushels for those sprayed with Bordeaux alone. In view of the fact that each of these treatments was repeated five times and that the differences noted were consistent throughout, the increase in yield must be attributed to the addition of the calcium caseinate to the Bordeaux mixture.

Test at Elmer

In this test with the Irish Cobbler variety, one series of plots was sprayed with 5-5-50 Bordeaux mixture on June 8, 21 and 30, a second series was sprayed July 10, 18, while a third series was sprayed on all of these dates. The check plots received one application of arsenate of lead on June 8. Following this date no Colorado beetles were observed in the field and no further applications of arsenicals were made.

No diseases were present until about June 30 when early blight made its appearance on the check plots with only a trace on those sprayed. This trouble never became severe but the first week of July there was a serious outbreak of leaf-hoppers. Counts of the number of dead leaves in the field on July 14 showed 50.3 per cent dead on the check plots; 5.4 per cent on those sprayed 4 times; 2.5 per cent, on those sprayed three times; and 27.7 per cent on the plots receiving one late spray application. As the season advanced the plots receiving the early spray application died, followed by those receiving the late applications. The plots sprayed five times remained green for a longer time than any of the others.

The yield of the various plots was check 169.3 bushels; sprayed five times, 201.7 bushels; sprayed three times (early), 218.2 bushels; sprayed two times (late), 189.5 bushels per acre.

Test with the Late Crop at Elmer

In this test, conducted at Elmer, a comparison was made of 5-5-50 home-made Bordeaux mixture prepared with stone lime and that prepared with hydrated lime (5-7.5-50), compared also with Bordeaux mixture plus calcium caseinate. The test was conducted with the Irish Cobbler variety. Four spray applications were made on the following dates, September 8, 18, 26 and October 5. The vines were very free from diseases until the first week of October when early blight made its appearance. On October 18 a careful examination was made of the various plots and the number of dead leaves noted. On the unsprayed checks 51.9 per cent of the leaves were dead and the remaining green leaves were heavily infected with early blight. On the plots sprayed with Bordeaux mixture made from stone-lime and on those sprayed with Bordeaux plus calcium caseinate, there were no dead leaves and no early blight. On the plots sprayed with Bordeaux made with hydrated lime, 7 per cent of the leaves were dead while most of the green leaves showed a slight infection of early blight.

The average yields of the various plots were check, 150.9 bushels per acre; Bordeaux made with stone-lime, 167.1 bushels; Bordeaux with hydrated lime, 156.2 bushels; and Bordeaux plus the calcium caseinate, 165.8 bushels.

In this test the addition of a calcium caseinate to the Bordeaux mixture was apparently of little value. This may possibly be explained on the ground that from the time of the first spray application until after the last one had been made there was no rainfall, so none of the various spray mixtures employed were washed from the leaves.

Test with the Late Crop at Bridgeton

In this test a comparison was made between Bordeaux mixture and copper-lime dust for the control of foliage diseases. The test was con-

ducted with the Irish Cobbler variety. Four treatments were made on the following dates, September 6, 15, 25 and October 5. The season was exceptionally dry, accounting in part for the failure to obtain increased yields from spraying with Bordeaux mixture.

An examination of the various plots on October 22 showed that on the unsprayed plots, 100 per cent of the leaves were dead, on the sprayed, 22.5 per cent, and on the dusted, 67.5 per cent. A few days after this observation was made the remaining green vines were killed by frost. The average yields of the various plots were; check, 159.8 bushels, sprayed, 149.0 bushels and dusted 149.3 bushels.

Additional Tests in 1922

During the summer and fall of this year, J. C. Crissey, County Agent of Salem County, conducted three spraying tests on early and three on late Cobblers. On the commercial crop there were some early blight and a heavy infestation of leaf hoppers, on the late crop early blight was quite severe.

In one of the tests with the commercial crop, plots sprayed four times with 5-5-50 Bordeaux mixture yielded 264.6 bushels per acre and those sprayed three times 244.3 bushels as compared with 199.3 bushels for the check plots.

In another test, three applications of Bordeaux gave a yield of 312.9 bushels as compared with 218 bushels for adjoining unsprayed check plots and in the third, three applications of Bordeaux gave an increase of 43.6 bushels per acre.

In the tests with late crop Irish Cobblers increased yields followed in every case. In one of the tests, plots sprayed three times yielded 210.8 bushels and those unsprayed, 144.6 bushels per acre. In the second test the plots sprayed three times yielded 229.1 bushels and those unsprayed 204.6 bushels while in the third, the yields were 201.2 bushels and 160.6 bushels for the sprayed and unsprayed plots respectively.

Discussion of Results

Spray Tests with the Irish Cobbler Variety

During the past ten years, twenty-three spraying experiments have been conducted in which the Irish Cobbler variety was sprayed with home-made Bordeaux mixture, of these nineteen resulted in increased yields and four in decreased yields. The results of these tests are shown in table 22. From the table it will be seen that increases in yield were secured in all of the spray tests beginning with 1919. These increases amounted to 10.9-94.9 bushels per acre. On the other hand, in four of the eleven tests conducted prior to 1919 the yield of the sprayed plots was less than that of those unsprayed and in three others the increases noted were small. These differences can probably be accounted for on the grounds that in some of the earlier tests a spray machine was used that developed only 50-60 lbs. pressure, while in those conducted since 1919 the machine employed for the work developed from 175 to 200 pounds pressure and was equipped to spray four rows at a time with three nozzles to the row. Furthermore the nozzle arrangement on the latter machine was such as to cover both the upper and lower leaf surfaces with a protective film of the spray. Suc-

cess in spraying is largely a question of methods; if the plants are not thoroughly covered, increased yields are not likely to follow.

TABLE 22

RESULTS OF SPRAYING TESTS WITH THE IRISH COBBLER VARIETY—1913-1922

Year	Yield per Acre		Number of Applications	Differences in Yield	
	Check	Sprayed with Bordeaux Mixture		In Favor of Sprayed Plot	In Favor of Check Plot
	bu.	bu.		bu.	bu.
1913	340.0	318.5	4	....	21.5
1914	212.7	275.6	4	62.9	...
1915	248.6	288.3	4	39.7	...
1915	393.7	389.1	4	....	4.6
1916	368.0	382.1	4	14.1	...
1916	217.8	225.2	4	7.4	...
1916	261.4	271.2	4	9.8	...
1917	175.1	178.5	3	3.4	...
1917	313.3	309.1	2	....	4.2
1918	154.0	148.7	3	....	5.3
1919	216.0	265.3	5	49.3	...
1920	260.3	281.4	5	21.1	...
1921	148.3	201.9	3	53.6	...
1921	148.3	229.5	4	81.2	...
1921	118.8	129.7	5	10.9	...
1921	118.8	132.9	3	14.1	...
1921	118.8	130.7	2	11.9	...
1922	169.2	201.7	5	32.5	...
1922	169.2	218.2	3	49.0	...
1922	169.2	189.5	2	20.3	...
1922	199.3	264.6	4	65.3	...
1922	199.3	244.3	3	45.0	...
1922	218.0	312.9	3	94.9	...
Average	214.7	242.9	..	28.2	...

The average increase from spraying with Bordeaux mixture in the years 1913 to 1918 inclusive, was 10.1 bushels as compared with 42.6 bushels for the years 1919 to 1922 and the average increase for all tests was 28.2 bushels per acre.

In this connection it must be noted that the increases noted were obtained from the control of early blight, tip burn, and in one test, from the control of hopper burn. Had late blight been present in the fields in which the spray tests were conducted, the average increases would doubtless have been considerably larger. The fact, however, that even in the absence of late blight there was an average increase of 28.2 bushels for the 10 year period and an increase of 42.6 bushels in the tests conducted since 1919 indicates the advisability of spraying the Irish Cobbler variety.

Tests with Late-Crop Irish Cobblers

In South Jersey it is a generally adopted practice to grow a late crop of potatoes planted between July 25 and August 10 to be used for seed the following spring. In the past eight years, sixteen spraying tests have been conducted with this crop and positive results were secured in all but one. In this one instance, a spray test conducted in 1922, the average yield of a series of plots sprayed with Bordeaux mixture was 10.8 bushels less than that of adjoining unsprayed check plots.

Differences between the sprayed and unsprayed plots were first apparent on October 22 when all of the leaves on the check plots were dead as compared with 25 per cent on the sprayed plots. The night following this observation the green vines were killed by frost thus precluding any possibility of increased returns following the spray application.

TABLE 23

Results of Spraying Late Crop Irish Cobblers—1915-1922

Year	Yield per Acre		Number of Applications	Gain per Acre	Loss per Acre
	Check	Bordeaux Mixture			
	bu.	bu.		bu.	bu.
1915	236.7	281 8	3	45.1	....
1916	154.7	163 5	..	8 8	....
1917	210.5	217.5	2	7.0	....
1919	132.6	183.4	4	50.8	....
1920	163.9	199.3	5	35.4	....
1920*	150.4	178.0	4	27.6	....
1921	125.0	163.5	6	38.5	....
1921	119.1	160.1	4	41.0	....
1921	161.0	213.5	4	52.5	....
1921	161.0	198.6	2	37.6	....
1921	162.7	213.4	3	50.7	....
1922	150.9	167.1	4	16.2	....
1922	159.8	149.0	4	....	10.8
1922	144.6	210.8	3	66.8	....
1922	204.6	229.1	3	24.5	....
1922	160.6	201.2	3	40.6	....
Average	162.3	195.5	..	33.2	....

*American Giant Variety.

The average yield of the plots sprayed with Bordeaux mixture in the different tests as well as the yield of adjoining unsprayed checks is shown in table 23. The average increase from spraying with Bordeaux mixture was 33.2 bushels per acre, the lowest increase noted was 7.0 bushels and the highest, obtained in 1922, 66.8 bushels per acre. Apart from the increased yield that can be expected there are other considerations which must not be overlooked. A film of Bordeaux protects the plant from insect attack and since it has been shown that some of the most serious diseases of the potato are disseminated by insects this factor is not to be overlooked, especially in view of the fact that the late crop is grown for seed purposes. Results of our studies indicate likewise that seed potatoes from sprayed vines will prove to be more vigorous than will tubers from similar unsprayed vines. In an experiment on this point, conducted in 1921, plants from tubers grown on unsprayed vines in 1920 showed on June 25 an average height of 11.5 inches with 45 per cent of the leaves yellow. On the other hand, the average height of vines on the plots planted with tubers produced on sprayed vines in 1920, was 13.2 inches with only 22 per cent of the leaves yellow. The average yield of the plots planted with tubers from the unsprayed plants was 34.8 bushels per acre as compared with 48.7 bushels for the tubers from the sprayed plants. In the light of these results there can be no longer any doubt as to the advisability of spraying the late crop.

Spray Tests with the American Giant Variety

The results from spraying the American Giant are presented in table 24. It will be seen from the table that in the five tests with this variety three gave positive and two, negative results.

TABLE 24

RESULTS OF SPRAYING TESTS WITH THE AMERICAN GIANT VARIETY—1914-1922

Year	Yield per Acre		Number of Spray Applications	Gain per Acre	Loss per Acre
	On Check Plot	On Plot Sprayed With Bordeaux Mixture			
	bu.	bu.		bu.	bu.
1914	283.3	286.6	4	3.3	...
1915	408.0	410.9	3	2.9	...
1916	372.4	369.2	3	...	3.2
1919	262.8	228.3	4	...	34.5
1922	280.9	350.3	7	69.4	...
Average	321.4	329.2	..	7.8	...

Tests were conducted in 1916 by H. C. Lint to determine if the differences in results obtained from spraying the American Giant and the Irish Cobbler varieties were due to varietal differences. The two varieties were planted in the same field, but unfortunately, the former received only three applications of Bordeaux mixture while the latter received four. The average yield of the Irish Cobblers that were sprayed was 9.8 bushels greater than the yield on adjoining unsprayed plots planted with the same variety. On the other hand, the average yield of the American Giants sprayed with Bordeaux mixture was 3.2 bushels less than the yield from similar unsprayed plants. In all of the tests with this variety conducted prior to 1922, the only foliage diseases present were light infections of early blight and tip burn, which probably accounts for the fact that greater increases were not obtained following spraying. In a test conducted in 1922, however, late blight was present and was quite severe. In this test seven applications of Bordeaux mixture gave an increase of 69.4 bushels as compared with the yield of adjoining unsprayed check plots. It is apparent from these results that when this disease is present in the field, spraying the American Giant would give satisfactory returns.

Spraying vs. Dusting

In the earlier spraying experiments with commercial crop Irish Cobblers various sulfur dusts were included to determine their value for the control of foliage diseases of the potato. The results of these tests indicated their inferiority to home-made Bordeaux mixture so no further mention of them need be made here. During the past two years tests have been conducted to determine the relative efficiency of copper-lime dusts and Bordeaux mixture for the control of foliage diseases of the potato.

This work was undertaken in view of the fact that many of the potato growers find it impossible to spray a large acreage since they are without an adequate supply of water. The saving of time arising from the adoption of this method of crop protection likewise favors its use should it prove to be satisfactory from the standpoint of disease control.

The first test with the copper-lime dust was with commercial crop Irish Cobblers in 1921. A 5-5-50 Bordeaux mixture was applied at the rate of 100 gallons per acre and adjoining plots were dusted with a copper-lime dust applied at a rate to give equivalent amounts of copper per acre to that contained in the liquid. In this test the average yield of the sprayed plots was 10.9 bushels greater than that of the checks, while the dusted plots gave no increase. In a second test conducted in 1921 with late planted Irish Cobblers, a similar comparison was made. In this test early blight and tip burn were abundant and severe on the check plots, only slightly less on the dusted, while these two diseases were much less severe on the sprayed plots. The latter plots showed an average increase of 38.5 bushels over the check plots as compared with increases amounting to 19.1 and 14.4 bushels for a 20-80 and a 15-85 dust respectively.

The third test to determine the efficiency of dusts was conducted with the American Giant variety in 1922. In this test exceptionally good control of late blight followed the use of home-made Bordeaux mixture while the plots dusted with a 6 per cent copper-lime dust were little better than the check plots. The home-made Bordeaux gave an increase of 69.4 bushels per acre, plots receiving three applications of the dust gave an increase of 19.8 bushels and those receiving 7 applications, a decrease of 20.2 bushels. On the latter plots more rotted potatoes were found than on any others included in the test. Had the yield of both sound and rotted tubers been taken the yield would probably have equalled that of the three dusted plots.

In view of the results secured from the tests with dusts, the use of these to replace the liquid sprays is not advised. Not only did the former give less efficient control of disease than the latter, but the cost of dusting an acre was more than twice the cost of spraying with home-made Bordeaux mixture. Growers who contemplate dusting should bear in mind that this method of plant protection has not yet been demonstrated to be satisfactory under New Jersey conditions.

Home-made vs. Commercial Bordeaux Mixture

In some of the spraying tests various commercial Bordeaux mixtures were included to compare their relative efficiency with that of home-made Bordeaux. Tests in which these comparative studies were made included the Irish Cobbler, Green Mountain and American Giant varieties. The results of these are presented in table 25. It will be seen from the table that, with the exception of one test conducted in 1919 with the Irish Cobbler variety, home-made Bordeaux has given greater returns than has the use of commercial mixtures. The average increase for the plots sprayed with the former was 19.1 bushels while the plots sprayed with the latter show a decrease amounting to 3.1 bushels when compared with adjoining unsprayed check plots.

The relative efficiency of home-made and commercial Bordeaux mixtures is clearly apparent as the result of a spray test with the American Giant variety, conducted in 1922. In this test late blight was present and was quite severe.

TABLE 25

VALUE OF COMMERCIAL AND HOME-MADE BORDEAUX MIXTURE FOR THE CONTROL OF FOLIAGE DISEASES OF THE POTATO

Year	Variety	Home-made Bordeaux Mixture		Commercial Bordeaux Mixture	
		Increase Over Check	Decrease	Increase Over Check	Decrease
		bu.	bu.	bu.	bu.
1913	Irish Cobbler...	....	21.5	....	26.2
1914	Irish Cobbler...	62.9	....	1.8	....
1914	American Giant.	3.3	....	....	1.7
1914	Green Mountain.	50.3	....	16.9	....
1915	Irish Cobbler...	....	4.6	1.3	....
1915	Irish Cobbler...	39.7	....	6.0	....
1916	Irish Cobbler...	14.1	....	7.3	....
1916	Irish Cobbler...	7.4	....	....	13.2
1916	Irish Cobbler...	9.8	....	....	33.4
1916	American Giant.	....	3.2	....	23.9
1917	Irish Cobbler...	....	4.2	3.0	....
1918	Irish Cobbler...	....	5.3	....	10.5
1919	Irish Cobbler...	49.3	....	52.6	....
1922	American Giant.	69.5	....	26.5	....
Average.....		19.1	....	....	3.1

Counts made on August 2 showed that 5 per cent of the leaves were dead on the plots sprayed with home-made Bordeaux mixture, while on adjoining plots, sprayed with a commercial mixture, applied at a rate to give equivalent amounts of copper per acre to that contained in the home-made mixture, 24 per cent of the leaves were dead. The average yield of the plots sprayed with the home-made was 42.9 bushels greater than that of the plots sprayed with commercial Bordeaux.

The results of the tests with these two materials indicate that the use of the home-made Bordeaux can be expected to give more efficient control of disease and consequently larger increases in yield than will the use of the commercial materials. An additional advantage of the former material lies in the fact that it is cheaper than the latter. Where difficulty is experienced in securing lime, however, or where small areas are to be sprayed, the use of a high grade commercial Bordeaux is sometimes advisable. The results of the 1919 test indicate that under some conditions, if sufficient of the commercial mixture is used, good results will follow.

Number of Applications

The number of spray applications necessary for maximum returns is dependent almost entirely on the nature and prevalence of the disease and the variety of potato to be sprayed. In some instances, and especially on early varieties such as the Irish Cobbler, four applications of Bordeau mixture have given excellent results. In these instances early blight and

tip burn were the only diseases present in the field in which the spray tests were conducted. In another instance, in a spraying test with the American Giant, a late variety, seven applications of spray were necessary to furnish adequate protection; in this instance late blight was present and was severe.

From table 22 it will be observed that there is considerable range in the average increase resulting from varying number of spray applications on the Irish Cobbler variety. A summary of the results of the various tests shows that the average yield of plots sprayed two times was 4.2 bushels less than that of check plots. On the other hand the average yield of the plots sprayed three, four and five times showed increases over the check plots amounting to 24.9, 34.9, and 28.4 bushels respectively. No definite information can be obtained from these results, due to the fact that in some years diseases were much more severe on the plants included in the experimental area than they were in others. The indications are, however, that for the Irish Cobbler or other early varieties, four to five spray applications should afford ample protection from diseases. The number of spray applications must be determined largely by local conditions. The importance of this is apparent from the spray test with the American Giant variety conducted in 1922. In this test, plots sprayed three times showed a decrease amounting to 9.1 bushels, while adjoining plots, sprayed seven times, showed increases amounting to 69.4 bushels. The failure of the plots receiving three applications to show greater returns is explained by the fact that late blight made its appearance in the field after the third application had been made. In view of the fact that late blight usually does not appear in New Jersey until late in June or the first of July, the early spray applications may possibly be omitted. If the first spray is applied when the vines are about 10 inches high, five to seven applications will probably protect the plant from diseases.

Time of Application

In the past two years tests have been conducted to determine the relative efficiency of early and late spray applications. In a test conducted in 1920 the average yield of plots receiving three applications of Bordeaux mixture early in the season showed a decrease of 11.1 bushels, as compared with the check plots, while adjoining plots sprayed three times late in the season showed an increase of 13.7 bushels. In a second test three early applications gave an increase of 14.1 bushels as compared with 11.9 bushels for plots sprayed two times, late in the season. In 1922, three early spray applications increased the yield 48.9 bushels while two late applications gave an increase of 20.2 bushels. In this test the vines were severely injured by leaf hoppers before the first of the two late spray applications were made.

From these results no definite conclusion can be drawn as to the most desirable time to make the spray application since, under certain conditions, the early, and under others, the late applications may be the more important. The results of these and of previously discussed tests indicate, however, that the ultimate aim should be to keep the vines covered. For best results the first spray application should be made when the plants are 8-10 inches high and subsequent applications at 10 to 14 day

intervals, depending on climatic conditions. If the weather is dry, applications made at 14-day intervals would probably suffice to keep the plants covered; if, however, there are frequent showers the applications should be made more frequently.

Strength of Bordeaux to Use

Since the introduction of Bordeaux mixture, various tests have been conducted to determine what strength of mixture should be used to give most efficient control of foliage disease. As the result of these tests the consensus of opinion seems to be that a mixture carrying 4 to 6 pounds of copper sulfate in 50 gallons of water will give the most satisfactory results. In 1921 a test was conducted to determine the relative efficiency of a mixture carrying 4 pounds and one carrying 5 pounds of copper sulfate per 50 gallons of water. Plots sprayed with the former material gave an increase of 5.7 bushels per acre as compared with 21.3 bushels for those sprayed with the latter. No attempt will be made to make recommendations from the results of one year of work, but the indications are that in New Jersey 5-5-50 Bordeaux mixture should prove to be superior to a 4-4-50 mixture for the control of early blight, tip burn and late blight.

In connection with this test, a comparison was made of a Bordeaux mixture prepared from unslaked lime and one prepared from hydrated lime. The yield of the plots sprayed with the former material was 167-1 bushels per acre, of those sprayed with Bordeaux made with hydrated lime 156.2 bushels and of the check plots 150.9 bushels. Early blight was quite severe on the check plots and, while the trouble was by no means as severe on plots sprayed with Bordeaux made from hydrated lime, almost every leaf was infected. No early blight was found on the plots sprayed with Bordeaux made from unslaked lime. It is apparent from these results that the use of stone lime for making Bordeaux mixture is to be advised over that of the hydrated lime. Where the former is difficult to secure, however, the hydrated lime may be substituted. If this is done one pound and a half of the latter material should be used to equal a pound of the unslaked.

Summary

Spraying tests with the Irish Cobbler variety conducted over a period of 10 years show an average increase in yield of 28.2 bushels per acre. In tests conducted since 1919 an average increase of 42.6 bushels resulted. These results were obtained in the absence of late blight.

Spraying tests with the American Giant variety in the absence of late blight have not resulted in increased yields. When late blight is present, however, considerable increases can be expected as is apparent from the fact that an average increase of 69.4 bushels per acre was secured in 1922.

Spraying tests with late crop potatoes grown for seed show an average increase of 33.2 bushels per acre. In addition to the increased yields the results of preliminary tests indicate that tubers from sprayed plants are more vigorous than tubers from similar unsprayed plants.

Bordeaux mixture will control early blight, late blight, reduce the damage from tip burn and act as a repellant to insects, especially the potato leaf hopper.

A 5-5-50 Bordeaux mixture has proved more satisfactory than a weaker mixture.

Comparative tests with home-made and commercial Bordeaux mixtures show that better control of foliage diseases will follow the use of the former. Where a small acreage is to be sprayed or where lime is not readily available the use of a high grade commercial Bordeaux mixture might be advisable.

The use of stone lime is advised for making Bordeaux mixture. Where stone lime is not available, however, hydrated lime may be substituted; in case this is done one and one-half pounds of the latter should be used to equal a pound of the former.

Tests with various sulfur dusts show that these materials will not protect the potato from fungous diseases. The results of tests with copper-lime dusts likewise indicate that these materials are inferior to home-made Bordeaux mixture.

The number of spray applications necessary for best results is dependent on the nature and prevalence of the disease as well as the variety of potato to be sprayed. Four to five applications on the Irish Cobbler variety should afford ample protection, while on the American Giant, a late variety, 5 to 7 applications will probably be necessary. The number of applications is dependent to a large extent on weather conditions. For best results the first application should be made when the vines are 8-10 inches high and subsequent applications made at 10- to 14-day intervals.

Success in spraying is largely a question of methods. In all spraying operations the points of importance are : (a) the proper mixture, (b) proper machinery, (c) adequate pressure, (d) sufficient nozzles, and (e) proper nozzle adjustment. For efficient protection the plants should be kept covered with a film of Bordeaux mixture.

Acknowledgment

The writer is indebted to Dr. Mel. T. Cook for the opportunity of conducting these tests. He is indebted to different potato growers, particularly J. Harry Kandle of Elmer, W. L. Minch and Frank Ott of Bridgeton, I. B. Van Derveer of Freehold and Theron McCampbell of Holmdel for their help. He also wishes to thank J. C. Crissey and Ellwood Douglass, county agents of Salem and Monmouth counties for their interest and hearty co-operation.